

Combining Early Childhood Education and Engineering Students to Create a Multidisciplinary Design Experience

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Abstract

Two professors at Ohio University decided to pursue a multidisciplinary design challenge through combining an early childhood development class with an engineering design class. The focus of the project was to allow the students to partner to accomplish an open ended design challenge. The challenge presented by the professors was to design and develop the engineering specification and collateral documentation to execute the fabrication of a museum display. The museum displays are targeted towards teaching early childhood through middle childhood integrated STEM topics.

The professors systematically grouped the students into 13 groups of 4-6 students from both early childhood education and engineering technology and management. The professors held a brief seminar with the students, where they explained the requirements of the design project as well as providing a brief overview of the scope of each of the classes. The students then participated in a team building exercise and a brainstorming exercise to determine the theme of their individual design projects.

Through the remainder of the course, the students collaborated to provide the documentation to allow an external party to fabricate the museum displays. Deliverables included engineering documentation such as the engineering drawings, bill of materials and failure modes and effects analysis. However, this project also required the inclusion of other documentation as well, such as a detailed product description of how the children would interact with the displays, signage for the displays and a take home activity for the children to allow the audience to further explore the concepts presented in the museum display.

The purpose of this project was to provide an open-ended and unstructured applied educational experience where students had to work with other students from a different background to accomplish a design challenge. The project took the students slightly out of their comfort zones, and it allowed them to create the design for a product that if constructed could be placed within a library, children's museum or school.

Vignette

It is a warm, sunny September day as two groups of students leave their classrooms on opposite sides of campus preparing to engage in a unique, cross-major collaborative project. After arriving at a building that is new for both majors, nervous energy fills the room as students file in to find their new partners. Sticking with their same-major partner, pairs of early childhood education and engineering design students search for the numbered table that will tell them where their group is meeting. Finding it, halting introductions give way to tentative smiles. For the next two hours, students participate in an interactive team-building activity, learn about each other's majors, explore ideas presented by museum professionals, and begin to brainstorm project ideas. By end of class, the room is noisy and laughter is heard erupting randomly from

groups around the room. The initial tension, while not totally gone, is noticeably less. Finally, contact information is shared and students make arrangements for their next planning meeting. Although some students exit the room with their same-major classmates, others leave with their newly formed design group. This represents the first step in what will be a semester-long, cross-major project that draws on the strengths and knowledge of both majors.

Rationale

This article describes the successful partnering of students from an engineering design class with students from an early childhood social studies methods course. Students were tasked with designing an interactive and open-ended museum quality exhibit for children that could be installed in a local informal learning setting. The project, which capitalized on the content expertise of both groups of students, demonstrates the value of fostering collaborative partnerships that positively impact student learning outcomes. While the collaboration was not always easy to facilitate, the professors of both courses pursued the project to provide their students with an authentic learning experience that facilitates collaborative practices and community engagement. The authors view this type of experience as essential to the success in their students' chosen majors once they leave an academic environment.

Cross-major collaborations such as the one presented in the opening vignette are not common between engineering and early childhood education students. Although collaborations between engineering students and education students are not often described in the scholarly literature, research strongly supports the efficacy of collaborative project-based learning to improve the learning outcomes of all participants (Chua, 2013; Dunlap, 2006; Johnson & Delawsky, 2013; Lee, Blackwell, Drake, & Moran, 2014; Mantri, 2013). Cross-major collaborations such as this one allow students an opportunity to demonstrate their content expertise and to build confidence in their field of study while simultaneously learning from their co-collaborators (Fitzgerald, Bruns, Sonka, Furco, & Swanson, 2015). Additionally, this experience engages all students in valuable project-based learning experiences with an emphasis on cross-content learning and professional development (Johnson & Delawsky, 2013; Lee et al., 2014). The experience also emulates a real-world interactions, where engineering design students work with clients and early childhood educators partner with parents/caregivers and other educational stakeholders to support the learning of children. Finally, the ability to work within an integrated group with people from diverse backgrounds and with varying experiences provides a meaningful learning opportunity that offers both groups of students experiences that they will certainly encounter in their future chosen professions.

Initial Meeting

The initial meeting with students is a critical point for the success of the student projects. The authors recommend not letting the students pick their own groups. Rather, it is recommended that groups be developed utilizing a more strategic approach to develop balanced teams. An instructor can do this if they know the general personality of each student. If this is not known, tools such as the CATME (found at www.catme.org); Comprehensive Assessment of Team Member Effectiveness team builder (Layton, Ohland, & Ricco, 2010). One additional benefit of using this free tool is the addition of robust peer evaluation throughout the project (Loughry,

Ohland, & Moore, 2007; Ohland, Woehr, Finelli, Bullard, Felder, Layton, Pomeranz, & Schmucker 2012). This tool was helpful in conducting peer/self evaluations during the final stages of the project and will help to inform the authors' future collaborative work together. The researchers of this project decided to hold the initial meeting and design reviews away from the typical building of each student. The intention was to provide a neutral area, where none of the students would feel that they have an advantage over the other students due to the location. Given the nervousness expressed by both groups of students, this helped to mitigate feelings of anxiety during the initial meeting.

Because this collaboration was between two very different majors, the researchers determined that they should provide an overview of the respective majors to each of the groups of students. This introduction provided an outline of the requirements and degree outcomes for each major and was an excellent way to ground the students with respect to what each of the other collaborators was able to contribute to the project. Overall, the intention of this overview was to obviate the roles and responsibilities of the students within the project.

It is important to provide each of the groups of students with a team-building activity to help integrate the groups of people into functional groups. A teambuilding activity helps to break the ice during the initial meeting and allows students to begin collaborating on a fun, risk-free task. An important component of the initial meeting was a workshop delivered by representatives from a local discovery museum. The museum representatives discussed several considerations that would be important considerations for the groups. Most importantly, they explored ideas related to creating exhibits that were open-ended and discovery-based. During the first meeting, the investigators of this project also provided each group with the project milestones and final project deliverables. The outcome for the first meeting was for each group to brainstorm ideas for their exhibit and to develop an initial concept idea. The second meeting was to present the overall project concept. The third meeting was to review the preliminary CAD for the project. The fourth and final meeting was to review all of the components of the project. The authors considered each of these meetings as a milestone towards the execution of the project, and each milestone was accompanied by a design review, which will be discussed below. Details about each meeting, activities and outcomes are described in Table 1.

Table 1*Collaborative Meeting Schedule (15-week semester)*

Meeting	Activities	Outcomes
Meeting 1 (Week 3)	Introductions, Description of project, Description of majors, Team building activity, Informal learning exhibit development workshop	Initial idea brainstorming, Sharing of contact information, Scheduling of future communications
Meeting 2 (Week 6)	Design review 1, Present preliminary sketches, Concept drawings, Exhibit description	Feedback from university faculty, classmates, and museum representatives
Meeting 3 (Week 10)	Design review 2, Present content standards, Developmental rationale, Take-home activity	Feedback from university faculty and classmates
Meeting 4 (Week 13)	Final exhibit presentation	Feedback from university faculty, classmates, and museum representatives

Learning Outcomes and Project Deliverables

The course goals of the Engineering design students included designing and developing the engineering specification to build a completely new product. Through this project, their product was the final design of the museum display. The other goal of the engineering students was to work with a collaborator to determine the design requirements and to pursue the execution of design reviews as a component of the engineering design process.

The course goals for the Education students included designing age appropriate educational experiences to teach STEM concepts to students between the ages of 3-10. The Education students as experts in their field were also required to collaborate with the Engineering students to design and develop age appropriate signage for the museum display as well as a take-home activity. The take-home activity is intended to allow unstructured exploration of the concepts presented in the museum display and provided another way for parents/caregivers to engage in the exhibit's educational content.

Collaborative Process

Part of the undefined learning objectives of this project were collaboration and time management skills. While the student teams were presented with milestones driven by requirements and deliverables, the investigators did not mandate or dictate how the teams were to work together to achieve these objectives. Many of the teams choose to use texting and collaborative group messaging applications such as GroupMe (<https://groupme.com/en-US/>). The frequency of the group meetings between design reviews was also variable between the groups. Each of the groups would meet at least once in between design reviews, with many of the groups meeting multiple times. Some groups communicated several times a week via texting or GroupMe.

The intention of the group meetings should have been not only to bring the groups together to review the work, but they should have also been used as an opportunity for the other students to provide input concerning the deliverables of the other students. For example, even though the Education students may not have been fluent with respect to reading engineering drawings and specifications, they should be able to understand the project enough to suggest design changes. The Engineering students may not be able to build take-home activities for the students, but they can certainly evaluate an activity and provide feedback and suggestions toward making the activity more engaging. While some groups experienced easy connections, other groups found it more difficult to navigate the collaborative process. Several challenges were experienced by groups during the collaborative process. These included finding time to meet, disagreements over design elements, and differing presentation styles. Despite these challenges, the extremely successful groups in this collaboration were the groups that effectively used their partners to evaluate their specific deliverables for the project. Many times, the act of reviewing changes based on the different perspective of a team member led to changes that enhanced the effectiveness of the project. By the completion of the project, the groups universally expressed satisfaction with their finished displays and were able to present a cohesive and unified finished design.

Example Product Descriptions

The students' collaborative work resulted in an integrated and professional design for a museum display that was ready for fabrication. Figures 1 and 2 provide descriptions for two exhibits that were developed by the collaborative groups. Both museum displays were appropriate for children ages 3-10 and allowed for involvement from parents/caregivers.

Our project has been named "Pipe Drumming." The design for our project includes a cart with different lengths of PVC pipes, which are standing upright so that the tops of the tubes are exposed. These PVC pipes will be the "drums" that the children are playing on during this activity. The sizing of the cart will be four by two with a short enough height that the children can stand on the ground and still hit the tallest pipes. We will be making two rows of pipes that will be facing back to back so a child can play with their parent or another child. The child's side will be two and a half feet off the ground, while the other side of the exhibit will be three and a half feet off the ground. Children will be able to interact with this exhibit by making contact with the tops of the pipes with drumsticks made of various materials. The purpose of making drumsticks of different materials is so the can children learn that the differences in texture can create a variety of different sounds. This exhibit can be installed in an indoor or outdoor location.

Figure 1. Example Exhibit Description as Provided by the Students

For our exhibit, we have chosen to create a discovery table. At this table, children explore and experiment with magnets through a couple of mediums. The first medium we're focusing on is ferrofluid, a fluid that contains magnetic suspension. In other words, it is a liquid that is attracted to magnets. This will be located in the outer ring of our table. When a child moves a magnet across the outer ring, the liquid inside will be attracted to the top. The second way that students will be able to explore magnets is through a shape maze. In the center of the table, there will be many different shaped magnets. Surrounding the magnets in the center will be a series of channels. These channels are designed in such a way that they will only allow specific magnets to travel through them. For example, a child may explore with a square magnet and will find that it is unable to fit down a rounded channel. This combines our overarching concept of magnets with early geometry. Children will work to discover which magnets fit through which channels, and if the shapes can fit through more than one. It is our intention that the discovery table ignites interest into more principles of science and magnetic properties. In the take-home activity, children will take what they learned at the exhibit and use it to make predictions about whether or not specific objects have magnetic properties.

Figure 2. Example Exhibit Description as Provided by the Students

Next Steps/Recommendations

Our next steps involve strengthening the peer review and evaluation portion of the project. We feel that we can work towards a more realistic business process if we couple the groups together for deeper peer evaluation. Currently, the students present to the class as a whole, however time constraints typically force this to being a relatively shallow interaction. Through the structured coupling of several groups together, we feel that the students will be able to understand those projects at a deeper level and provide more valuable external review of the projects.

The researchers involved in this study are working to turn this program into a yearly event. We hope that we can build a stream of museum displays that can be replicated and deployed in many venues. We will be continuing to develop new ways to fund these experiences and working with other collaborators to continue to add value to the exhibits.

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